JC17 Rec'd PCT/PTO 29 MAY 2001

FORM PTO-1390 (REV 10-94) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		9320.131USWO
		US APPLICATION NO (If known, see 37 CFR 1 5) Unknown 09/856894
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FR00/00081	January 14, 2000	January 14, 1999

TITLE OF INVENTION

CODING AND DECODING BY ITERATIVE FUNCTION SYSTEMS (IFS) WITH OSCILLATING COLLAGE FUNCTIONS AND A SPATIAL COLLAGE FUNCTION

APPLICANT(S) FOR DO/EO/US

ROBERT et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [X] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND of SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information: International Preliminary Examination Report; International Search Report; Front page of PCT application

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U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
Unknown 09/856894	PCT/FR00/00081	9320.131USWO

17. [X] The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a) (1)-(5)): Search Report has been prepared by the EPO or JPO **$860.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.492(a)(1)) **$690.00**		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) **$710.00**		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(3)) paid to USPTO **$1000.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	**$0**	

CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE		
Total claims	14	-20 =	0	X **$18.00**	**$0**	
Independent claims	5	-3 =	2	X **$80.00**	**$160.00**	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ **$260.00**	**$0**	
TOTAL OF ABOVE CALCULATIONS =					**$1020.00**	
Reduction by 1/2 for filing by small entity, if applicable. Small entity status is claimed pursuant to 37 CFR 1.27					**$0**	
SUBTOTAL =					**$1020.00**	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f). +					**$0**	
TOTAL NATIONAL FEE =					**$1020.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +					**$0**	
TOTAL FEES ENCLOSED =					**$1020.00**	
					Amount to be: refunded	**$0**
					charged	**$0**

a. [X] Check in the amount of $1020.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ________________ in the amount of $ ____________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-2725.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO
John J. Gresens
MERCHANT & GOULD
P.O. Box 2903
Minneapolis, MN 55402-0903

SIGNATURE: [signature]

NAME: John J. Gresens

REGISTRATION NUMBER: 33,112

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S/N unknown

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	ROBERT et al.	Docket No.:	9320.131USWO
Serial No.:	unknown	Filed:	concurrent herewith
Int'l Appln No.:	PCT/FR00/00081	Int'l Filing Date:	January 14, 2000
Title:	CODING AND DECODING BY ITERATIVE FUNCTION SYSTEMS (IFS) WITH OSCILLATING COLLAGE FUNCTIONS AND A SPATIAL COLLAGE FUNCTION		

CERTIFICATE UNDER 37 CFR 1.10
'Express Mail' mailing label number: EL669941704US
Date of Deposit: May 29, 2001
I hereby certify that this correspondence is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

By: Brant Miles
Name: ~~Omesh Singh~~ BRANT MILES

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment (marked-up copy attached):

IN THE ABSTRACT

Insert the attached Abstract page into the application as the last page thereof.

IN THE SPECIFICATION

A courtesy copy of the present specification is enclosed herewith. However, the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

IN THE CLAIMS

Please amend the following claims:

8. (Amended) Image encoding method according to claim 1, characterized in that said mass collage function w_M is written in the form of a combination of oscillating functions whose number and/or frequency and/or amplitude can be parametrized.

14. (Amended) Application of the method according to claim 1 to at least one of the fields belonging to the group comprising the following fields:

- compression of fixed images;
- compression (of images) in "intra" mode in a video encoder;
- compression of images or of a part of the images that are textured;
- magnification (zooming) of image zones;
- compression in spaces having a size greater than 2.

REMARKS

The above preliminary amendment is made to remove multiple dependencies from claims 8 and 14.

A new abstract page is supplied to conform to that appearing on the publication page of the WIPO application, but the new Abstract is typed on a separate page as required by U.S. practice.

Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, John J. Gresens (Reg. No. 33,112), at (612) 371.5265.

Respectfully submitted,

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Dated: May 29, 2001

By [signature]
John J. Gresens
Reg. No. 33,112

JJG/tvm

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8. (Amended) Image encoding method according to [any of the claims 1 to 6] claim 1, characterized in that said mass collage function w_M is written in the form of a combination of oscillating functions whose number and/or frequency and/or amplitude can be parametrized.

14. (Amended) Application of the method according to [any of the claims 1 to 8] claim 1 to at least one of the fields belonging to the group comprising the following fields:

- compression of fixed images;
- compression (of images) in "intra" mode in a video encoder;
- compression of images or of a part of the images that are textured;
- magnification (zooming) of image zones;
- compression in spaces having a size greater than 2.

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CODING AND DECODING BY ITERATIVE FUNCTION SYSTEMS (IFS) WITH OSCILLATING COLLAGE FUNCTIONS AND A SPATIAL COLLAGE FUNCTION

The field of the invention is that of the encoding and especially the compression of the volume of an image, with loss of information, for example for its storage and/or its transmission.

The notion of image compression with loss is a concept well known in the field of image processing. The main problem encountered is of course that of obtaining an approximation of the original image that is as faithful as possible while minimizing the volume of the approximation. To express the gain on a volume of data, the general practice is to introduce the notion of the bit rate whose unit is one bit per pixel (bpp). The bit rate therefore defines the ratio between the number of pixels of the original image and the number of bits needed to reconstruct its approximation.

The invention also relates to applications requiring image encoding at low bit rates (for example at rates of below 0.3 bpp), for example applications on the Internet. Of course, as shall be seen hereinafter, the invention can be applied to many other technical fields.

Indeed, the invention provides a major improvement in fractal compression techniques, also known as compression based on iterated function systems (IFS). The principle of image compression by the IFS method relies on the expression of the contents of the image by means of these contents themselves. It can therefore be seen as a self-quantification of the image.

The formalizing of the IFS method has come especially through work by Hutchinson, published in 1981 and by Bransley, Demko and others, researchers at the Georgia Institute of Technology, between 1985 and 1988. The first automatic algorithm applying these principles to image compression was proposed by Jacquin in 1989.

The general principle of this algorithm relies on the partitioning (subdividing) of the image I to be encoded into destination regions (also known as ranges). This partitioning can be predefined or it can depend on the contents of the image. Then, for each of the destination regions, the following operations are performed:

- the choice (according to several known techniques) of another larger-sized region of the image, not necessarily a partition element, known as a source region (or domain);

- the determining of the spatial collage function, in a family of spatial collage functions fixed beforehand, that transforms the support of the source region so as to make it capable of being superimposed on the destination region to be considered.

  If there is no corresponding function, there is a return to the previous step. Otherwise, the result of the application of the spatial collage function identified on the source region is called a decimated source region;
- determining the mass collage function, in the family of mass collage functions fixed beforehand, which transforms the contents (for example the color and/or the gray level and/or at least one piece of photometric information) of the destination source region so as to make it as close as possible to that of the destination region considered.

  If the proximity is not satisfactory, the first preceding step is resumed.

The set of spatial and mass collage functions thus chosen is called IFS. These spatial and mass collage functions are essentially refined functions. The term "collage function" is generally applied to the pair formed by the spatial collage function and the mass collage function applied to a source region.

Let I_R be an image with any contents, having the same support as the image I used to construct the IFS. The successive applications of IFS to I_R are used for the convergence (for example in about ten iterations) towards a "fixed point" that is an image I' close to I. This property is the basis of image-encoding by IFS. Indeed, it is enough to memorize the IFS in order to characterize I'.

However, while maintaining the general principle presented here above, much research has been done in order to improve the performance characteristics of the first IFS-based encoders.

In particular, it has been proposed to make adaptive partitions for the destination regions. Such partitions are used to pave the image with small regions on textured zones that are difficult to approximate and to pave the image with large regions on the less dense zones which are easier to approximate.

Another advance is the hybridization of the IFS methods with other methods of image compression such as wavelets, vector quantification (VQ) or discrete cosine transform (DCT).

An IFS-wavelet hybridization consists of a search for similarity between the sub-bands of a breakdown into wavelets of the original image.

An IFS-VQ hybridization considers the IFS as a self-quantification of the image, and seeks to quantify the source regions of the IFS determined on the original image.

Finally, an IFS-DCT hybridization seeks for example to express the similarities of the coefficients of the DCT-transformed destination regions with source regions which too are transformed by DCT. An IFS-DCT hybridization of this kind may also consist of the application of an IFS computation to the residual image of a DCT reconstruction or again, conversely, the application of an approximation by DCT to the residual image of a reconstruction by IFS.

These different known techniques are relatively efficient in many situations. However, they have defects of analysis and synthesis, when they have to process zones with high frequencies and/or a textured content, especially when a very low bit rate is sought.

The goal of the invention especially is to overcome these drawbacks of the prior art.

More specifically, a goal of the invention is to provide an image-encoding method implementing IFS techniques that is more efficient, especially in terms of visual quality of approximation, and especially for the processing of high frequencies and textured zones while maintaining performance on the other zones.

Another goal of the invention is to provide an encoding method of this kind that is simple to implement with a reasonable quantity of computations. In particular, a goal of the invention is to provide an encoding method of this kind that can derive benefit from the advantages of the known techniques referred to here above in providing increased scalability.

It is also a goal of the invention to provide a corresponding decoding method which, as the case may be, can be parametrized.

These goals as well as others that shall appear hereinafter are achieved by means of an image-encoding method implementing iterated function systems (IFS), said method comprising the following steps:

- the partitioning an image I to be encoded into a set of image regions, known as destination regions, having an arbitrary shape (rectangular, triangular, or the like);

- the association, with each of said destination regions D, of a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D,

said collage function being broken down into:

- a spatial collage function w_S, acting on the position and/or the geometry of said source region S in order to create a decimated source region $\overline{S}$ (we have: $\overline{S} = w_S(S)$); and
- a mass collage function w_M, acting on the contents (for example the color and/or the gray level and/or at least a photometrical information element) of said decimated source region $\overline{S}$.

According to the invention, the mass collage function w_M is an oscillating function.

The invention therefore relies on a novel, inventive approach to collage. Indeed, whatever the technique used, it has always been considered that only the polynomial functions (which include especially the refined functions) could be used in this context.

The use of oscillating functions is used to obtain efficient results especially for the processing of regions containing high frequencies. Thus, it is possible to faithfully reconstruct textures in avoiding the use of smoothing common to known IFS techniques.

Advantageously, said mass collage function w_M is a harmonic function, and for example a cosine function.

In this case, a transformed source region S' = w(S) may advantageously be defined by:

$$S'_i = w(S_i) = \sum_{l\in[0;N_c[} \sum_{k\in[0;N_c[} c_{kl} \times \overline{S}_i \times \cos(\theta_l i_x) \times \cos(\theta_k i_y) + b$$

where:

i is the index of the ith pixel of S', having co-ordinates (i_x, i_y);

$\overline{S}_i$ is the image of S_i with reference to w_S;

θ is a real vector of R^{Nc} such that $\theta_j = 2\pi/2^j$;

c_{kl} and b are the coefficients characterizing collage function (the coefficients c_{kl} represent the amplitudes and b represents the shift).

Said coefficients c_{kl} and b may then be determined by searching for the coefficients minimizing an error between source and destination. This error E is written for example as follows:

$$E = \sum_{i \in [0;card(D)[} (S'_i - D_i)^2$$

with:

Card(D) being the number of pixels of D.

Various computation techniques may be used. In particular, it is possible to implement a matrix linear system whose approaches are determined by means of said methods belonging to the group comprising a:

- direct method;
- iterated method;
- gradient method.

According to a preferred embodiment of the invention, a direct Gauss pivot method or Cholesky pivot method is implemented.

Advantageously, said mass collage function w_M is written in the form of a combination of oscillating functions whose number and/or frequency and/or amplitude can be parametrized.

The invention also relates to an image encoding device implementing this method as well as the collage function itself, in which the mass collage function w_M is an oscillating function.

The invention also relates to the method of decoding images encoded by means of the encoding method described here above. According to this decoding method, said images are reconstructed by carrying out at least one iteration of said collage function applied to said corresponding source region S, said mass collage function w_M being an oscillating function.

According to a preferred embodiment of the invention, the mass collage function applied to said decimated source region during the decoding takes account of a number of oscillating functions smaller than or equal to the number taken into account during the encoding.

Thus, it is possible to carry out a progressive decoding and/or a scalability (ability to be sampled) during the decoding.

The invention also relates to data carriers containing images encoded according to the technique described here above (only said source regions S and said collage functions being stored on said data carrier).

The invention can be applied in many fields, especially in the fields belonging to the group comprising the following fields:

- compression of fixed images;

- compression (of images) in "intra" mode in a video encoder;
- compression of images or of a part of the images that are textured;
- magnification (zooming) of image zones;
- compression in spaces having a size greater than 2.

Other features and advantages of the invention shall appear more clearly from the following description of a preferred embodiment given by way of a simple illustrative and non-restrictive example, and the appended drawings which provide an illustration, in one example, of the principle of encoding by IFS:

- Figure 1 shows an original image to be compressed I;
- Figure 2 illustrates the construction of a partition on the original image of Figure 1;
- Figure 3 illustrates a search for a fixed region D of the region S and of the collage w that most closely approximates it;
- Figure 4 illustrates the determination of the collage function W of Figure 3.

The invention therefore relates to an improvement of IFS-based techniques. It may be recalled that this technique, which is known per se, seeks to express the self-similarities of an image.

For example, figure 1 shows an original image that is to be compressed.

In the first processing step, a partition of the original image is made, as shown in figure 2, in the form of square-shaped regions or blocks. The partitioning can also be done from another basic pattern, especially triangles. It can also be adaptive, i.e. it can take account of the contents of the image, and especially of the complexity of the different parts of this image.

Then, for each region D31 of the partition, a search is made for the region S (32, 33 or 34) and the collage w that most closely approximates it, as is shown in figure 3.

In the example shown, it is the region S_2 33 that meets this criterion.

Figure 4 illustrates the principle of the collage function w. This collage comprises first of all a spatial collage w_s, that shifts, decimates and orients the region

33 so that it geometrically approaches the region 31. Then, the mass collage function w_M is used to obtain the region 41 S'_2, approximating the region 31.

More specifically, when we consider the destination region D 31, the resolution consists in characterizing a source region 33 as well as a collage function w, such that w(S) is a close approximation of S. In a particular case, if S'=(S) and if the error measurement considered is the distance L_2, then the error to be minimized is defined by:

$$E = \sum_{i\in[0;card(D)[} (S'_i - D_i)^2$$

where S'_i (and D_i respectively) is the intensity of the ith pixel of S' (and D respectively), and where card(D) is the number of pixels of D.

The collage function can be subdivided into two sub-functions. The first is the spatial collage w_s which acts on the position and geometry of the regions. It transforms the source region into a decimated region $\bar{S}$. The second is the mass collage w_M which acts on the contents of the regions. It transforms the decimated source region $\bar{S}$ into a region S' most closely approximating the region D considered in the sense of the error defined here above.

The invention relates to the nature of the mass collages w_M.

According to the known techniques, these operations of mass collage w_M are polynomial functions (which include especially the refined functions). More specifically, they bring into play two variables α and β called a scale factor and an offset factor.

It has also been envisaged to use polynomial mass collages or collages defined by function trees. However, these techniques have proved to be inefficient or highly complex, and, therefore, especially, unsuited to image compression in grey levels.

According to the invention, oscillating mass collage functions are used. In the embodiment described here below, by way of an example, cosine collage functions are used.

This approach introduces high frequencies into the IFS collages, when the contents of the source regions is not sufficiently dense. The collage of the invention optimizes the characterization of the source regions in conjunction with the coefficients associated with the cosine functions. Thus, the source regions provide the low frequency information as well as the breaks in slope such as the contours, that are enriched by the cosine functions, if the destination region considered comprises high frequency information.

If we consider a destination region D and a source region S, it is possible to conventionally determine a spatial collage w_S. The image $\bar{S}$ is called the image of S by w_s.

The contents of the transformed source region S' approximating D can be expressed, according to the approach of the invention, as follows:

$$S'_i = w(S_i)$$

$$S'_i = w_M(w_S(S_i))$$

$$S'_i = w_M(\bar{S}_i)$$

$$S'_i = \sum_{l \in [0;N_c[} \sum_{k \in [0;N_c[} c_{kl} \times \bar{S}_i \times \cos(\theta_l i_x) \times \cos(\theta_k i_y) + b$$

where: i is the index of the i^{th} pixel of S', having coordinates (i_x, i_y) ;

$\bar{S}_i$ is the image of S_i by w_s ;

θ_j is a real vector of R^{Nc} such that $\theta_j = 2\pi/2^j$;

c_{kl} and b are coefficients characterizing the collage function.

The characterization of w_M is obtained by the determining of the values of amplitude of the cosines represented by a matrix, and of the offset b, represented by a scalar value.

These values must minimize the collage error E between S' and D.

The expression to be minimized is therefore the following:

$$\min E = \min \sum_{i\in[0;card(D)[} (S'_i - D_i)^2$$

The minimum of this error E, which is strictly positive, may be obtained for the coefficients c_{kl} and b which cancel the derivative of E. The problem is therefore expressed by the resolution of the following system of $(N_c^2 + 1)$ rows and $(N_c^2 + 1)$ unknown quantities:

$$\begin{cases} \dfrac{\partial E}{\partial c_{00}} = 0 \\ \cdots \\ \dfrac{\partial E}{\partial c_{ij}} = 0 \\ \cdots \\ \dfrac{\partial E}{\partial c_{Nc-1;N_c-1}} = 0 \\ \dfrac{\partial E}{\partial b} = 0 \end{cases}$$

After the development of the expressions, this system can be rewritten in the form of a matrix linear system.

$$A\begin{pmatrix} A_{00}^{00} \cdots\cdots A_{0N_c-1}^{00} \; A_{10}^{00} \cdots\cdots\cdots\cdots A_{N_c0}^{00} \\ \vdots \\ A_{00}^{0N_c} \\ A_{00}^{1N_c} \\ \vdots \\ A_{00}^{N_cN_c} \cdots A_{0N_c-1}^{N_cN_c} \; A_{10}^{N_cN_c} \cdots\cdots\cdots A_{N_c0}^{N_cN_c} \end{pmatrix} * X\begin{pmatrix} c_{00} \\ \vdots \\ \vdots \\ \vdots \\ c_{N_c-1N_c-1} \\ b \end{pmatrix} = B\begin{pmatrix} B_{00} \\ \vdots \\ \vdots \\ \vdots \\ B_{N_c-1N_c-1} \\ B_{N_c-1N_c} \end{pmatrix}$$

Where $A\in \mathcal{M}^{N_c^2+1}(\Re)$ is a known expression defined as follows :

$$\begin{cases} A_{ij}^{kl} = \displaystyle\sum_{m\in[0..card(D)[} \overline{S}_m^2 * \Psi_m^{ij} * \Psi_m^{kl}, & \forall\, i\in[0..N_c[\,,\; j\in[0..N_c[\,,\; k\in[0..N_c[\,,\; l\in[0..N_c[\\ A_{ij}^{N_cN_c} = \displaystyle\sum_{m\in[0..card(D)[} \overline{S}_m * \Psi_m^{ij}, & \forall\, i\in[0..N_c[\,,\; j\in[0..N_c[\\ A_{N_c0}^{kl} = \displaystyle\sum_{m\in[0..card(D)[} \overline{S}_m * \Psi_m^{kl}, & \forall\, k\in[0..N_c[\,,\; l\in[0..N_c[\\ A_{N_c0}^{N_cN_c} = card(D) \end{cases}$$

Taking $\Psi_m^{ij} = \cos(\theta_i * m_x) * \cos(\theta_j * m_y)$

with $m_x;m_y$ being the local co-ordinates of the mth pixel of D

Where $B \in \Re^{N_c^2+1}$ is a known vector, defined as follows :

$$\begin{cases} B_{ij} = \sum_{m \in [0..card(D)[} \bar{S}_m * D_m * \Psi_m^{ij} \quad pour\ i \in [0..N_c[\quad j \in [0..N_c[\\ B_{N_c-1N_c} = \sum_{m \in [0..card(D)[} D_m \end{cases}$$

This system can be resolved by different methods (direct method, iterated method, gradient method etc). In particular, it is possible to use the GAUSS pivot method.

Efficient encoding results are obtained with a very small number of coefficients. Two or three basic oscillating functions already give good results. Naturally, the greater this number, the higher is the quality.

During the decoding, it is possible to take account of a smaller number of oscillating functions. With this, it is possible to take account of the processing capacity of the receiver or of the user's needs, but also to carry out a gradual decoding (the image being first of all reconstructed with average quality and then being gradually refined). This also gives scalability during the decoding.

The technique of the invention can be used in very many fields, including that of image compression, especially when it has some textured parts. The invention also makes it possible to obtain zoom operations, by modification if the partition at decoding.

The invention can be applied also to image processing in spaces with a dimension of over 2 (for example in video (2D+t) or in virtual images (3D)). It can also be implemented for one-dimensional images

CLAIMS

1. Image-encoding method implementing iterated function systems (IFS), said method comprising the following steps:

- the partitioning an image I to be encoded into a set of image regions, known as destination regions,
- the association, with each of said destination regions D, of a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D,

said collage function being broken down into:

- a spatial collage function w_S, acting on the position and/or the geometry of said source region S in order to create a decimated source region $\overline{S}$; and
- a mass collage function w_M, acting on the contents of said decimated source region $\overline{S}$.

characterized in that said mass collage function w_M is an oscillating function.

2. Image encoding method according to claim 1, characterized in that said mass collage function $w_M$is a harmonic function.

3. Image encoding method according to claim 1, characterized in that said mass collage function w_M is a cosine function.

4. Image encoding method according to claim 3, characterized in that a transformed source region S' = w(S) is advantageously be defined by:

$$S'_i = w(S_i) = \sum_{l \in [0;N_c[} \sum_{k \in [0;N_c[} c_{kl} \times \overline{S}_i \times \cos(\theta_l i_x) \times \cos(\theta_k i_y) + b$$

where:

i is the index of the ith pixel of S', having co-ordinates (i_x, i_y);

$\overline{S}_i$ is the image of S_i according to w_S;

θ is a real vector of R^{Nc} such that $\theta_j = 2\pi/2^j$;

c_{kl} and b are coefficients characterizing the collage function.

5. Image encoding method according to claim 4, characterized in that said coefficients c_{kl} and b are determined by searching for the coefficients minimizing an error between source and destination, said error being written as follows:

$$E = \sum_{i \in [0;card(D)[} (S'_i - D_i)^2$$

with: Card(D) being the number of pixels of D.

6. Image encoding method according to claim 5, characterized in that it implement a matrix linear system whose solutions are determined by means of one of the methods belonging to the group comprising a:

- direct method;
- iterated method;
- gradient method.

7. Image encoding method according to claim 6, characterized in that it implements a direct Gauss pivot method or Cholesky pivot method.

8. Image encoding method according to any of the claims 1 to 6, characterized in that said mass collage function w_M is written in the form of a combination of oscillating functions whose number and/or frequency and/or amplitude can be parametrized.

9. Image-encoding device implementing iterated function systems (IFS) comprising:

- means for partitioning an image I to be encoded into a set of image regions, known as destination regions D,
- means for the association, with each of said destination regions D, of a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D,

said collage function being broken down into:

- a spatial collage function w_S, acting on the position and/or the geometry of said source region S in order to create a decimated source region $\overline{S}$; and
- a mass collage function w_M, acting on the contents of said decimated source region $\overline{S}$,

characterized in that said mass collage function w_M is an oscillating function.

10 Collage method, implemented in a method for the encoding and/or decoding of digital data representing images, implementing iterated function systems (IFS), said method comprising the following steps:

- the partitioning of an image I to be encoded into a set of image regions, known as destination regions,
- the association, with each of said destination regions D, of a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D,

said collage method implementing a collage function broken down into:

- a spatial collage function w_S, acting on the position and/or the geometry of said source region S in order to create a decimated source region $\overline{S}$; and
- a mass collage function w_M, acting on the contents of said decimated source region $\overline{S}$,

characterized in that said mass collage function w_M is an oscillating function.

11. Method of decoding images encoded by means of an encoding method implementing iterated function systems (IFS), said encoding method comprising the following steps:

- the partitioning an image I to be encoded into a set of image regions, known as destination regions,
- the association, with each of said destination regions D, of a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D,

said collage function being broken down into:

- a spatial collage function w_S, acting on the position and/or the geometry of said source region S in order to create a decimated source region $\overline{S}$; and
- a mass collage function w_M, acting on the contents of said decimated source region $\overline{S}$.

characterized in that said mass collage function w_M is an oscillating function, and in that said images are reconstructed by carrying out at least one iteration of said collage function applied to said corresponding source region S.

12. Decoding method according to claim 11, characterized in that the mass collage function applied to said decimated source region during the decoding takes account of a number of oscillating functions smaller than or equal to the number taken into account during the encoding.

13. Data carrier containing images encoded according to an image-encoding method implementing iterated function systems (IFS), said encoding method comprising the following steps:

- the partitioning an image I to be encoded into a set of image regions, known as destination regions,
- the association, with each of said destination regions D, of a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D,

said collage function being broken down into:

- a spatial collage function w_S, acting on the position and/or the geometry of said source region S in order to create a decimated source region $\bar{S}$; and
- a mass collage function w_M, acting on the contents of said decimated source region $\bar{S}$.

only the position and/or the geometry of said source regions S and said collage functions being stored on said data support;

characterized in that said mass collage function w_M is an oscillating function,

14. Application of the method according to any of the claims 1 to 8 to at least one of the fields belonging to the group comprising the following fields:

- compression of fixed images;
- compression (of images) in "intra" mode in a video encoder;
- compression of images or of a part of the images that are textured;
- magnification (zooming) of image zones;
- compression in spaces having a size greater than 2.

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JC18 Rec'd PCT/PTO 29 MAY 2001

ABSTRACT

Title: CODING AND DECODING BY ITERATIVE FUNCTION SYSTEMS (IFS) WITH OSCILLATING COLLAGE FUNCTIONS AND A SPATIAL COLLAGE FUNCTION

The invention concerns an image-coding method using iterated function systems (IFS), said method comprising the following steps: partitioning an image I to be coded into a set of image regions, called destination regions; associating with each of said destination regions D a corresponding source region S and a collage function w such that w(S) is a good approximation of said destination region D; said collage function being broken down into: a spatial collage function w_S, acting on the position and/or the geometry of said source region S; so as to produce a decimated source region S; and a mass collage function w_M, acting on the contents of said decimated source region S, said mass collage function w_M being an oscillating function.

Inventor: ROBERT et al.
Docket No.: 9320.131USWO
Title CODING AND DECODING BY ITERATIVE FUNCTIONS SYSTEMS (IFS) WITH OSCILLATING COLLAGE FUNCTIONS AND SPATIAL COLLAGE FUNCTION
Attorney Name: John J Gresens
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Sheet 1 of 1

09/856894

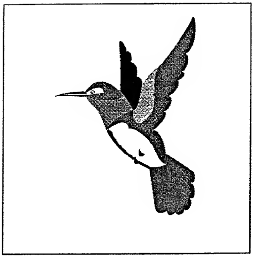

Fig 1

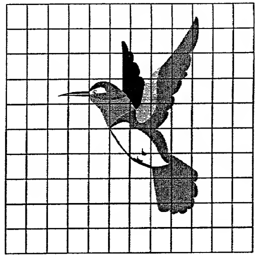

Fig 2

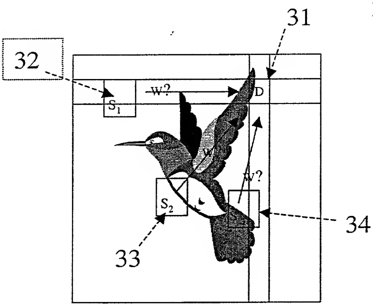

Fig 3

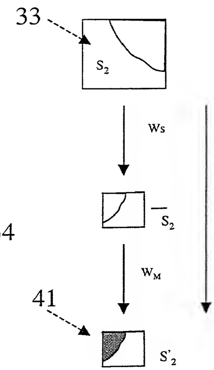

Fig 4

Attorney Docket No. 9320.131USWO

MERCHANT & GOULD P.C.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: CODING AND DECODING BY ITERATIVE FUNCTION SYSTEMS (IFS) WITH OSCILLATING COLLAGE FUNCTIONS AND A SPATIAL COLLAGE FUNCTION

The specification of which
a. ☐ is attached hereto
b. ☒ was filed on as application serial no. and was amended on (if applicable) (in the case of a PCT-filed application) described and claimed in international no. PCT/FR00/00081 filed January 14, 2000 and as amended on (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

a. ☐ no such applications have been filed.
b. ☒ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	**APPLICATION NUMBER**	**DATE OF FILING (day, month, year)**	**DATE OF ISSUE (day, month, year)**
France	99 00656	14 January 1999	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	**APPLICATION NUMBER**	**DATE OF FILING (day, month, year)**	**DATE OF ISSUE (day, month, year)**

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. APPLICATION NUMBER	**DATE OF FILING (day, month, year)**	**STATUS (patented, pending, abandoned)**

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

U.S. PROVISIONAL APPLICATION NUMBER	**DATE OF FILING** (Day, Month, Year)

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (reprinted below):

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application:

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

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Kowalchyk, Katherine M.	Reg. No. 36,848	Xu, Min S.	Reg. No. 39,536
Lacy, Paul E.	Reg. No. 38,946	Young, Thomas	Reg. No. 25,796
Larson, James A.	Reg. No. 40,443	Zeuli, Anthony R.	Reg. No. 45,255
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I understand that the execution of this document, and the grant of a power of attorney, does not in itself establish an attorney-client relationship between the undersigned and the law firm Merchant & Gould P.C., or any of its attorneys.

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23552
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